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National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2015/011

SCIENCE GUIDANCE FOR FISHERIES PROTECTION POLICY: ADVICE ON EQUIVALENT ADULT CALCULATION

Figure 1: Department of Fisheries and Oceans' (DFO) six administrative regions.

Context:

Amendments to the Fisheries Act (2012) (FA) came into force in 2013. These amendments change the way that Fisheries and Oceans Canada (DFO) assesses and manages impacts on aquatic ecosystems. The amended FA focuses on the sustainability and ongoing productivity of commercial, recreational or Aboriginal fisheries.

DFO Program Policy Sector has requested scientific guidance to inform and support the implementation of these amendments to the FA. DFO Science has undertaken a series of meetings in which participants review scientific information related to potential changes in fisheries productivity due to human development, and provide scientific advice to the Fisheries Protection Program (FPP). Previous advice, particularly the Science Advisory Report (SAR) on risk and productivity (DFO 2014, d), proposed that "Equivalent Adult (EA)" might be useful in some aspects of implementation of the amendments to the FA. This proposal was taken up by FPP, leading to a request from them on using "EA" and production foregone in the decision-making framework they are developing.

In response to that request DFO Science organized a Science Advisory Meeting from June 9-10, 2014 in Burlington, Ontario. The ***Objectives*** *of the meeting were to address the following questions from FPP:*

1. *Is it feasible to use an equivalent adult approach as a common metric for discussing impacts to habitat quantity and/or quality on freshwater Canadian fish?*
2. *Is it feasible to use fish production (or production forgone) as a common metric for discussing impacts to habitat quantity and/or quality?*
3. *What are the appropriate groupings of data (e.g., body size and ecosystem type)?*
4. *What are the preliminary estimates of the amounts of habitat (e.g. orders of magnitude) required to produce one equivalent adult in the appropriate groupings identified in #3?*
5. *If both approaches are feasible, are there circumstances where one may be more appropriate than the other?*

This Science Advisory Report is from the June 9-10, 2014 National Peer Review on "Science Guidance for Fisheries Protection Policy: Advice on Equivalent Adult Calculation". Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

May 2015

Canada

SUMMARY

- Consistency in decision making by FPP would be aided by the development of a methodology that can place a diverse range of impacts on a single scale with respect to their effects on fish and fish habitat. Such methodologies would benefit from having a 'common currency' for measurement or estimation of fishery productivity.
- The preferred options for projects are first to avoid impacts on fish or fish habitat and second to minimize unavoidable impacts. The advice in this SAR is for cases where feasible options for avoidance and minimization of potential impacts have all been applied, and there is still a risk of some degree of serious harm.
- The goal of these analyses was to develop a 'common currency' related to fisheries productivity that could be used to inform and standardize the development of regulatory thresholds or decision points for the FPP. It was concluded that the approach has promise, but the quantitative results of the current analyses are still preliminary in nature. However, the conceptual approach and analytical methods were considered to be a sound foundation for estimating metrics for these uses.
- Use of area per recruit (APR) estimates in setting thresholds or triggering decisions on appropriate regulatory pathways will support decisions for generic cases, but their robustness for specialized cases needs to be explored.
- Risk-based thresholds based on area associated with a chosen number of recruits (i.e., 1 APR, 5 APR, etc.) can be identified using continuous cumulative frequency distributions, or through the use of quantile (or other interval) analysis.
- Both the preliminary compilation of data and the generic analysis suggest most APR estimates range from 100-1000 m^2 for freshwater fish species typical of Canadian freshwaters (Figure 2). Smaller values were associated with riverine species, and for species of small body size that occur at high density. Expansion of the existing dataset and the inclusion of regional or ecological covariates are likely to result in more accurate and precise estimates of APR.
- Production foregone, the production of biomass ($g \cdot m^{-2} \cdot y^{-1}$) provided a complementary metric of productivity to equivalent adults but it was not an alternative to APR.
- If sufficient data are available, and if the scale of the project warrants a detailed assessment, production foregone may be a preferred alternative to AE, as production accounts for all biomass contributions to ongoing productivity, including the biomass of fish that die during the time interval but become available to other trophic levels.
- At present the coarse estimates at national scale are the best information available for general use, and indicate that the EA approach is feasible for coarse level binning of projects. The currently available estimates of APR range from 100-1000 m^2. The order of magnitude range in estimates conveys a sense of their uncertainty in any particular project review situation. Factors other than APR (such as, regional fisheries objectives, habitat quantity) will also apply. Research is underway that may clarify appropriate habitat type or regional stratification criteria and scales and the resultant reduction in uncertainty.
- If EA relationships do differ among habitats or regionally, then the estimates from pooling data from the various habitats or regions would have greater uncertainty. Hence a risk-based framework managing risks at coarse levels of stratification will require that APR thresholds triggering higher levels of regulatory review be set lower (less area potentially impacted) than if the estimates were more precise.
- Although the scientific basis for the use of adult equivalents and, when appropriate, forgone productivity is sound, the data available to this meeting for estimating values for these metrics

come from a limited subset of species, habitat types, and regions. Hence there is uncertainty about how robust the quantitative estimates would be if used in management. Additional data sources were identified during the peer review process, and these are being added to the data base used in the analyses. In the meantime, the order of magnitude range of these estimates is supported by the currently available data and analyses and could be used with the appropriate level of caution given the level of uncertainty.

BACKGROUND

Priorities and Potential Uses by FPP

In 2012, legislative amendments were made to the fisheries protection provisions of the *FA* including new terminology and new sections. These provisions apply to works, undertakings or activities that have the potential to cause serious harm to fish. DFO's FPP conducts reviews of projects that pose a risk of serious harm to fish and the habitat that supports them. When undertaking these reviews, the FPP is guided by the fisheries protection provisions, including section 6.1 of the *FA*, which states the purpose of decision-making under the provisions is to "provide for the sustainability and ongoing productivity of commercial, recreational and Aboriginal (CRA) fisheries". Science advice on the technical meanings of these terms is provided by DFO (2013, 2014b) and supporting documents.

The FPP is developing a project review and decision making process that has the goals of providing a consistent, transparent, and efficient approach to the application of the fisheries protection provisions. These goals are aided by the development of quantitative metrics that can be coupled with decision criteria to assist FPP staff when determining whether to authorize serious harm to fish (DFO 2014d).

Sections 6 and 6.1 require FPP to consider impacts of projects on fish and fish habitat in terms of their effects on fisheries productivity when reviewing an application for authorization. Development activities can have a wide range of impacts on fish and fish habitat, from direct mortality of fish, reductions in the quantity and quality of habitat, and changes to life history processes such as growth or survival as a result of stress or non-optimal environmental conditions (DFO 2014a).

Consistency in decision making by FPP would be aided by the development of a methodology that can place a diverse range of impacts on a single scale with respect to their effects on fisheries productivity. Such methodologies would benefit from having a 'common currency' for measurement or estimation of fishery productivity. The use of a common currency could assist in the development of regulatory thresholds that are consistent across activity types. Converting ecosystem damages to a common metric is also central to some applications of the Habitat Equivalency Analysis (HEA; Allen et al. 2005) that can be used for the determination of offset requirements (Clarke and Bradford 2014).

It is stressed that these types of decisions, on application of regulatory thresholds for managing impacts or estimating habitat equivalencies for potential impacts are decisions made later in the hierarchy of decisions regarding projects that may impact fisheries productivity. The preferred option for projects is to avoid impacts on fish and fish habitat[1], and to minimize unavoidable impacts. The advice in this SAR is for cases where feasible options for avoidance and minimization of potential impacts have all been applied, and there is still a risk of some degree of serious harm.

[1] In this SAR, in some places the term fish (or fisheries) productivity is used, and other places the reference is fish and fish habitat. Both phrases appear in different places in the amendments to the *FA*, and in the FPP. Earlier SARs related to the FPP were developing the scientific framework for implementing the amendments, and generally used the term "fisheries [or fish] productivity" in its general sense. In this SAR, the advice is often discussed in the specific operational context of decisions regarding authorization of projects causing serious harm to fish, which is linked to death of fish, and impacts on fish habitat, that are part of or support a commercial, recreational or Aboriginal fishery. In that specific context the FP Policy in particular, makes specific reference to "fish and fish habitat" as the feature for which determinations of authorization must be made. Hence when this SAR is advising relative to that specific context, the term "fish and fish habitat" will be used.

For projects where avoidance has not been possible, and impacts are minimized to the extent feasible, the priority needs expressed by FPP are for methods to estimate the potential impacts of development projects on fish or fish habitat that could be used to assist in the regulatory process. The needs include:

- Easy to communicate tools to help DFO staff follow a consistent process when making decisions about whether or not a project requires an authorization;
- Science advice to help guide application of the prohibition against serious harm to fish, in support of sustainability and ongoing productivity of fisheries;
- Science advice to help inform the parts of a national or regional level screening decision tool that deal with the quantity and quality of fish habitat. The Screening decision tools will support decisions for whether an authorization will be required or whether an alternative regulatory pathway (e.g., a letter of advice) will be used to manage impacts to fish and fish habitat that are part of, or support, CRA fisheries; and
- Although the focus of the present advice is to inform development of a screening decision tool, methods that could be adapted to provide quantitative estimates of project impacts, for use in detailed site-specific regulatory reviews or calculation of offsetting requirements, when simple habitat-based measures are inadequate, represent additional needs of the FPP.

Definitions

Equivalent adults (EA): The number of adults that are expected to be produced from a given number of eggs, larvae or juveniles. Equivalent adults is a metric to scale human-induced losses in the early life history to their consequences in terms of adults. "Adults" in this context is normally numbers of recruits (to the fishery or reproductive stock); but could also be defined in terms of the adult biomass, or yield to the fishery. EA estimates as discussed in this SAR are annual values.

Area per recruit (APR): The area of nursery habitats in a stream or lake required to produce one adult recruit with recruits defined as reproductively mature fish. APR is not the minimum area required to produce one fish but an integration of the area over all life stages required to produce an adult and this is influenced by variations in habitat quality, biotic interactions, and body size. APR can generally be expressed as the ratio of the area of nursery or juvenile habitat and the estimated average annual number of recruits. APR can also be calculated from the observed density of juveniles in nursery areas and the expected survival from the juvenile to the recruitment stage.

Production foregone: The biomass that would have resulted from the survival and growth of the fish production lost to a project (e.g., entrainment or impingement mortality, loss of rearing habitat to infill). As with EA, biomass accumulation values (production) are annual.

ASSESSMENT[2]

Equivalent Adults

Concept and Potential Uses

Two approaches to estimate the habitat area associated with the production of a single recruit to the adult reproductive population (i.e., Area per Recruit - APR) were reviewed. The empirical approach summarizes published fish density and survival data for freshwater fishes of northern North America (mainly Canada and US border-states) to generate APR estimates by species for individual lakes or

[2] The use of "Assessment" is a mandatory heading in all CSAS SARs. It represents an assessment of the questions posed in the Terms of Reference for the meeting that produced the SAR, and not an assessment of habitats or their productivity.

streams. Results were summarized using cumulative probability distributions to allow consideration of uncertainty and to illustrate the potential for developing risk-based thresholds. The preliminary data compilation included 56 APR estimates for 20 species.

The second approach used generic body-size based life history modelling and allometric relations between density and body size to predict APR for generic freshwater fish of four length categories. Because the observed densities of fish are higher in rivers than in lakes, and to be consistent with an empirical approach to FPP implementation, APR was calculated separately for each habitat type. Uncertainty in life history parameters and densities were incorporated in the computation of APR resulting in a distribution of APR values for each fish length and habitat type (i.e., rivers or lakes in the cases reviewed) under consideration.

The range in ecosystem productivity, physical habitat characteristics, and diversity in fish life history and community interactions contribute to the wide range of APR values in the empirical analysis. Small-bodied fishes in productive ecosystems have the smallest values because they occur at high densities, and thus require smaller amounts of habitat per recruit. In contrast species that are larger as adults often occur at lower densities with correspondingly larger APR values. Species that are scarce for ecological reasons (unsuitable physical habitat conditions or as a result of biotic interactions) also yield large APR values but these values likely greatly exceed the minimum habitat area required to produce an adult fish for habitats considered generally suitable for the species.

The goal of these analyses was to develop a 'common currency' related to fisheries productivity that could be used to inform and standardize the development of regulatory thresholds or decision points for the FPP. It was concluded that the approach has promise, but the quantitative results of the current analyses are still preliminary in nature, and the development of accurate and precise quantitative advice on thresholds awaits a more complete compilation of data and finalization of the modelling. However, the conceptual approach and analytical methods were considered to be a sound foundation for estimating metrics for these uses.

The current APR calculations are based on average fish densities for near-shore lake and wadable river habitats and do not reflect the role of more productive or specialized habitats or any unique requirements that some species may have. Data sources on the densities and APR related primarily to nursery rearing habitat (for feeding and growth), not to spawning habitat or migration corridors. Use of APR estimates in setting thresholds or triggering decisions on appropriate regulatory pathways will support decisions for generic cases (cases for which self-assessment or assisted assessment tolls may be applied), but their robustness for specialized cases (when such standardized decision support tools are not appropriate) needs to be explored. It is expected that guidance will be needed on the conditions that would be appropriate for initial use of the more generic tools. In addition, tools using the more generic estimates also may need internal triggers that alert users when more specialized analyses will be necessary to achieve the desired protection of fisheries productivity.

A risk-based approach will be needed for establishing regulatory guidelines. In the context of determining the nature of regulatory review, smaller area thresholds mean that more proposed works or undertakings are likely to exceed the threshold, and as a result be subject to more detailed review. Consequently in such risk-based approaches, greater risk aversion would be achieved through smaller APR thresholds. The approach would account for the variability in species and ecosystems by setting standards and guidelines that take into account uncertainty in APR estimates. Risk-based thresholds based on area associated with a chosen number of recruits (i.e., 1 APR, 5 APR, etc.) can be identified using continuous cumulative frequency distributions, or through the use of quantile (or other interval) analysis. For example, if the median (50^{th} percentile) APR value were selected (in Figure 2, it would be 700 m^2 for lake habitat), in about half of the cases the number of recruits potentially affected by the project will be greater than the planned number. If the threshold is reduced to a lower percentile (for example the 20^{th} percentile in Figure 2, 200 m^2 for lake habitat), the risk of an effect being larger than planned (in this case the numbers of affected recruits being greater than one) is reduced accordingly. If the precision of APR estimates can be increased (reducing uncertainty through the collection of more

data, or stratification of the data [see below]), then risk can be managed with higher triggers for regulatory decisions for a given level of risk aversion.

APR was initially investigated to help inform the establishment of decision criteria based on habitat quantity and quality for FPP's regulatory program. However, it was recognized that the approach is also likely to have value at later stages in the assessment process for the calculation of project impacts on fisheries productivity, and potentially for the determination of offset requirements. The computation steps would be the same, but their use in assessing equivalence of offsetting options would require additional considerations (DFO 2014c). In such project-specific applications the approach could be used with site-specific information, or regional standards that include, for example, an appropriate level of data stratification to include species- or habitat-specific information relevant to the project under consideration.

Calculations can be directly applied to situations where habitat no longer has the capacity to produce fish, as a result of an infill or a major alteration to its characteristics. For cases where habitat alterations reduce the potential productivity of fish habitat, there is the potential to pro-rate these impacts to estimate potential impacts on adult production. Simple scalars, adapted from habitat suitability index methodologies may prove useful in this context. For example, if a habitat is modified such that its capacity to produce adult recruits is reduced by 50%, then an approximate estimate of the impact on the production of adults would be one half of the calculation based on the complete destruction of the habitat area.

Estimates

Both the preliminary compilation of data and the generic analysis suggest most APR estimates range from 100-1000 m^2 for freshwater fish species (Figure 2). Smaller values were associated with riverine species, and for species of small body size that occur at high density. Expansion of the existing dataset and the inclusion of regional or ecological covariates are likely to result in more accurate and precise estimates of APR. It was noted the existing dataset had few examples of Atlantic or Pacific salmon, species that, when present, are generally significant for FPP decision making. Because of the incompleteness of the data sets from which they were derived, at present these estimates are illustrative. The data sets on which the analyses are based are not sufficiently representative of Canadian watershed for the quantitative results to be treated as accurate or precise. However the results convey the type of results expected and the order of magnitude of expected patterns. More complete guidance on their use in supporting regulatory decision-making will be provided when estimates based on an augmented data set and/or appropriate stratification have been developed.

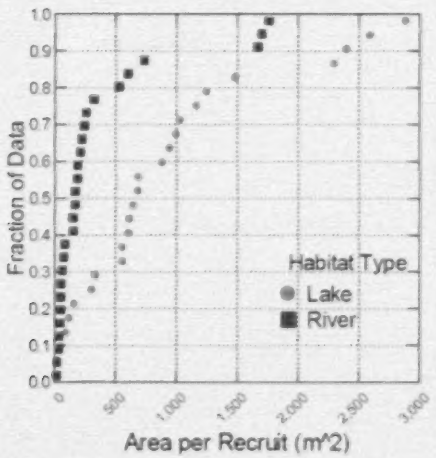

Figure 2. The cumulative distributions of area per recruit values for lake and river habitats, based on the data set available to the meeting.

Foregone Production

Consistent with equivalent adults, the measurement of fish production of all life stages leading to adult recruitment that is foregone would provide an ecologically sound and complementary metric to the numbers of adults lost. Production is more relevant for ecosystem assessment than numbers lost because it includes the energy that could potentially be transferred to other trophic levels through consumption or decomposition. Production forgone recognizes that losses to ecosystem productivity are both immediate and propagated through time.

Estimates

Production estimates always have a spatial (habitat area) and temporal (time interval) context. To test feasibility and to be consistent with the questions posed in this SAR, annual production (biomass) was estimated for two species, a river population of juvenile Atlantic salmon and a lake population of yellow perch. For each species, annual production in terms of total biomass accumulation was successfully estimated for the habitat area equivalent to one adult (APR), including the juveniles that would be lost to natural mortality. Generic production models based on body size were also calculated and shown to be feasible, but the estimates had low precision (Figure 3).

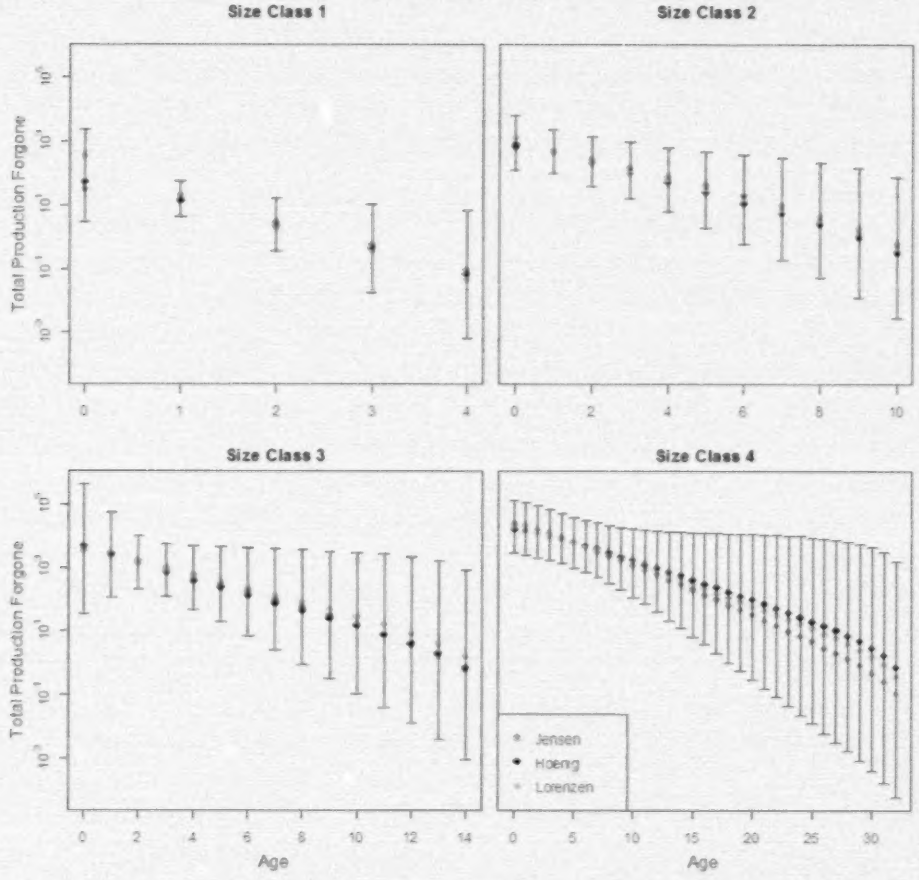

Figure 3. Total production forgone ($g \cdot APR^{-1} \cdot y^{-1}$) for the loss of the number of individuals equal to one adult at the age-of-maturity. Size classes were: Class 1 <20 cm; Class 2 20-40 cm; Class 3 40-70 cm; and Class 4 > 70 cm. The error bars represent 95% confidence intervals.

The production of biomass ($g \cdot m^{-2} \cdot y^{-1}$) provided a complementary metric of productivity to equivalent adults but it was not an alternative to APR. Calculation of equivalent adults infers an underlying production rate, *implicitly*, whereas production rate is an *explicit* part of calculating production of biomass.

Although feasible to measure if sufficient data are available, production is not a reasonable substitute for equivalent adults as a metric to guide initial regulatory decisions. Estimating production requires detailed data on densities and biomass of all cohorts potentially affected by the project area in the specific habitat and geographic area, and therefore is data demanding.

Because of the convergence of calculations of equivalent adults and production forgone, for the FPP decision process, production forgone will be useful as a metric for later stages in the decision framework if a detailed assessment and computation of offset requirements is required. If sufficient data are available, and if the scale of the project warrants a detailed assessment, production foregone may be a preferred alternative to EA, as production accounts for all biomass contributions to ongoing productivity, including the biomass of fish that die during the time interval but become available to other trophic levels because either the cause of death was predation or the carcass was scavenged.

Stratification rationale and criteria for use with either type of metric

The "equivalent adult" approach was based on average fish densities derived from literature values generally collected in feeding and rearing habitats. The analysis did not evaluate the role of habitat quality or specialized habitats on the resulting APR. Habitats that provide a specific function (e.g., spawning) or are potential bottlenecks for the population (e.g., thermal refugia, and overwintering) could potentially have higher densities at specific times during the life cycle. Such areas of substantially higher (or lower) density relative to more typical areas have implications for both estimation of equivalent adults or production forgone, and for use of those estimates. With regard to estimation, stratifying data sources by relevant ecological factors (described in the following paragraphs) is likely to produce estimates of greater accuracy and precision for use within the areas consistent with the stratification factors. With regard to use of the estimates, destruction of these high density (or otherwise especially ecologically significant) areas could be expected to have a disproportionate effect on population productivity, and this consideration needs to be taken into account when setting the level of risk aversion of these ecologically important areas.

Habitat Stratification

A constraint of using literature based values was that most of the available information came from wadable rivers and littoral zones of lakes. While these areas in general are among the more productive areas for freshwater fishes, if the regulatory decision-making encounters requirements to become more sensitive to local conditions other habitat stratifications may be needed. Currently the only stratification factor applied to the data was the separation of lake and river habitat. This is consistent with the known productivity differences of these two broad habitat classifications. Other stratifications based on region, lake and river size would probably refine the approach. Work is currently ongoing to inform the estimation of regional benchmarks of productivity, which should be available in the winter of 2015.

If the "equivalent adult" approach was to be used in the assessment and/or setting of offsetting requirements even further stratifications may be needed. These subdivisions may include habitat specific information such as the difference between littoral and pelagic zones in lakes, stream order (zonation) or species specific differences based on expected movement and habitat use patterns. Although it was recognized that these finer scale stratifications of habitat types might improve the EA estimates, working at these finer scales would require more data and additional analyses. The EA approach can be applied without such stratification by habitat type. However, if EA relationships do differ among habitats, then the estimates from pooling data from the various habitats would have greater uncertainty. Hence in a risk-based framework managing risks at coarse levels of stratification

will require that APR thresholds triggering higher levels of regulatory review be set lower (less area potentially impacted) than if the estimates were more precise.

While the EA approach may be expandable to other habitats where density effects are known, three conditions were identified that if applicable would place specific habitats outside of the equivalent adult framework. First, when the habitat functions independent of density, there will be no basis for converting habitat use to an equivalent adult estimate. Examples of these types of habitats include migration corridors or larval drift conditions (where the important attributes are flow and river length). Second, when the potentially affected habitats are unique or rare and even small losses will unduly affect the species these habitats support (e.g. the only spawning bed that supports a population). Third, when the habitat is not directly used by fishes but generate the conditions necessary for their sustainability and ongoing productivity (e.g., wetlands, riparian or headwater habitats). Each of these types of conditions requires different modifications to the generic approach, and guidance will need to be developed for each type. In addition, other conditions requiring special treatment may emerge as experience with the EA approach is gained.

Regional Stratification

Fish species or fish assemblages that contribute to the ongoing productivity of fisheries across Canada are region[3]-specific. Region-specific data and thresholds may be useful for regulatory decision-making, and may improve the precision of estimates or thresholds beyond the current coarse habitat split of rivers versus lakes. The effect of geographic regions on the estimation of equivalent adults and production forgone still needs to be tested, and built into the tools and decision framework if needed. More information on regional benchmarks of productivity is expected to be available in the future. At present the coarse estimates at national scale are the best information available for general use, and their order of magnitude range (100-1000 m^2) conveys a sense of their uncertainty. Research is underway that may clarify appropriate regional stratification criteria and scales and the resultant reduction in uncertainty.

Choice of Species or Communities

Past advice on the Productivity – Response framework discussed the possibility that P-R curves for both generic and project-specific uses might be based on P-R relationships of single well-chosen species (DFO 2014a,b). For decisions that are to be based on a single species within the affected habitats, consideration was given to alternative options for choosing appropriate species as the basis for these decisions. Options included but are not limited to:

(i) A representative species,
(ii) The smallest species, or
(iii) A consistent size-class of species.

Choosing a representative CRA species provides a clear link to program objectives making it easier to communicate the basis for decisions. However, no single species could be identified that is equally applicable to all regions of Canada, and probably no such species exists. Choosing the smallest species is clearly aligned with being protective of the most sensitive species in an ecosystem as smaller fishes were associated with greater losses of equivalent adults per unit of habitat. However, these species will not often be the target species for local commercial, recreational or Aboriginal fisheries. Choosing a consistent size-class of species allows decisions to be based on body size which is associated with sensitivity to habitat loss. Analyses were completed on the basis of four size-classes, with average adult body sizes of < 20 cm, 20-40 cm, 40-70 cm, and > 70 cm. The 20-40 cm size class

[3] In this context "region" is used descriptively. It should not be interpreted as either the administrative Regions of DFO operations, nor as any specific eco-regional classification system. The sensitivity of several aspects of the FPP framework, including these estimates, to different geographic stratifications of Canada's watersheds is currently being investigated, and will be reported in future advice.

has the advantages that most tertiary watersheds in Canada contain a species in this size-class that can be identified for communication purposes, many species in this size-class are targeted by a fishery, and protecting this size-class of fish will also be protective of larger fishes. When more than one species shares a habitat, the area estimates based on a single species will under-estimate the production of equivalent adults per unit of habitat.

Decisions based on the community of fishes likely to be present at a site may have the added advantage of also protecting ecosystem function. A potential approach to basing decisions on the fish community is to use the cumulative frequency distribution of the area per recruit for all fishes in a community. This approach involves ranking species from lowest to highest area per recruit requirements. This would produce an estimate of the area required to produce one adult recruit of any species from the community. Choosing a lower percentile will be more risk-averse, and protective of a greater proportion of the fish community. The forms of these cumulative frequency distributions may differ among regions and habitats. When the data base for estimating APR is augmented as described in the section on "Estimates", this approach will be explored in more depth.

Sources of Uncertainty

Although the scientific basis for the use of equivalent adults and, when appropriate, production forgone is sound, the data available to this meeting for estimating values for these metrics come from a small set of species, habitat types, and regions. Hence there is uncertainty about how robust the quantitative estimates would be if used in management. Additional data sources were identified during the peer review process, and these are being added to the data base used in the analyses. In addition, the work underway on stratification by region and habitat types, and on differences among species in their APR and related metrics should contribute to reducing these sources of uncertainty. However the residual uncertainty in parameter estimates once the stratification factors have been applied to a larger data set is unknown, and may not be small.

CONCLUSION AND ADVICE

Equivalent adults and production foregone are methods to scale losses or alterations of certain types of fish habitat in terms of impacts to fishery productivity and are potentially useful for setting decision guidelines or communicating decision rationale to affected parties. Additional work is needed to determine how accurate and precise the metrics could be, establish guidelines for their use and set risk tolerances based on uncertainty.

OTHER CONSIDERATIONS

Equivalent adults can be used as a metric of productivity for the productivity-state (P-S) response curves (DFO 2014b). However, as used in the literature for mortality and as considered here for loss of habitat quantity, a linear response with the stressor is assumed. As a result of previous work to describe the general shapes of P-S response curves (DFO 2014b), it is not expected that productivity will respond linearly to many stressors that affect habitat quality. For non-linear responses, if the application of a stressor is operating in the region of a plateau of the P-S response curve, then equivalent adults would not be an appropriate metric. However, non-linear P-S response curves have regions that approximate a linear response. It is in these approximately linear regions where equivalent adult is an appropriate metric.

To apply the equivalent adult metric to stressors that affect habitat quality, it will be necessary to first determine if the state of the habitats being affected are in the P-S response curve regions with approximately linear responses (i.e., not in the region of a plateau), and second to identify the rate of change in these approximately linear regions. To extend the equivalent adult framework to

considerations of habitat quality, it may be sufficient to identify when an approximately linear response is expected and an applicable scalar.

SOURCES OF INFORMATION

This Science Advisory Report is from the June 9-10, 2014 National Peer Review on "Science Guidance for Fisheries Protection Policy: Advice on Equivalent Adult Calculation". Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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DFO. 2014d. Science Advice for Managing Risk and Uncertainty in Operational Decisions of the Fisheries Protection Program. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/015.

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Canadian Science Advisory Secretariat (CSAS)
National Capital Region
Fisheries and Oceans Canada
200 Kent Street
Ottawa, ON K1A 0E6

Telephone: 613-990-0293
E-Mail: CSAS-SCCS@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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